LESSON STUDY CHARACTERIZED AS A MULTI-TIERED TEACHING EXPERIMENT[1]

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Japanese lesson study, in various adapted forms, is becoming increasingly significant in professional development of mathematics teachers in the USA. Our goal in the research reported in this paper was to investigate, in a three-tiered teaching experiment, the cycles of learning of two researchers, six teachers, and the students in three grade 4 classes and three grade 5 classes, in a six-month long lesson study project in the first half of 2002. The learning processes evolved in each of the three tiers (students, teachers, and researchers) over the course of three iterations of a lesson on measurement taught respectively in grades 4 and 5 by the three grade 4 and three grade 5 teachers. This paper documents some of these shifts in learning in each of the three tiers and assesses this form of lesson study for professional development, through the eyes of the teachers.

IMPROVING THE TEACHING OF MATHEMATICS THROUGH LESSON STUDY

Although it is recognized that adaptations are necessary in using traditional Japanese lesson study in a different country where the culture and values may not be congruent with those of Japanese society (Stigler & Hiebert, 1999), the assumption is sometimes made that this form of professional development will be universally beneficial. In our research we set out to investigate in a systematic way the processes that take place over the course of several iterations of the same lesson, with planning and debriefing sessions preceding and following each iteration, for the purpose of assessing what is learned by teachers in this form of professional development. As researchers, our own learning was a central element in the study. And for both teachers and researchers, the learning of the grade 4 and grade 5 students in the study was the reason for the project in the first place. Thus a multi-tiered teaching experiment (Lesh & Kelly, 2000), which takes account of the learning of students, teachers, and researchers, was an appropriate choice of methodology, as will be elaborated in the following sections.

Conceptual framework.

The conceptual framework of the research is drawn from theoretical and empirical fields (Brown & Dowling, 1998). In the theoretical domain, our literature base includes the books by Stigler and Hiebert (1999) and Liping Ma (1999), both of which were supplied to and studied by the team of teachers prior to the commencement of the lesson study. The research was also informed by the growing lesson study literature in the USA (Fernandez et al., 2001; Lewis, 2000; Murata & Takahashi, 2002). The conceptual framework embraced "six principles for gradual, measurable improvement through lesson study" (Stigler & Heibert, 1999):

1. Expect improvement to be continual, gradual, and incremental.

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2. Maintain a constant focus on student learning goals.
3. Focus on teaching, not teachers.
4. Make improvements in context.
5. Make improvements the work of teachers.
6. Build a system that can learn from its own experience (pp. 132-136).

Some of these principles will be re-visited in discussing the results of the study.

In the empirical field, a three-tiered teaching experiment (fig. 1) was structured as follows (adapted from Lesh & Kelly, 2000, p. 211).

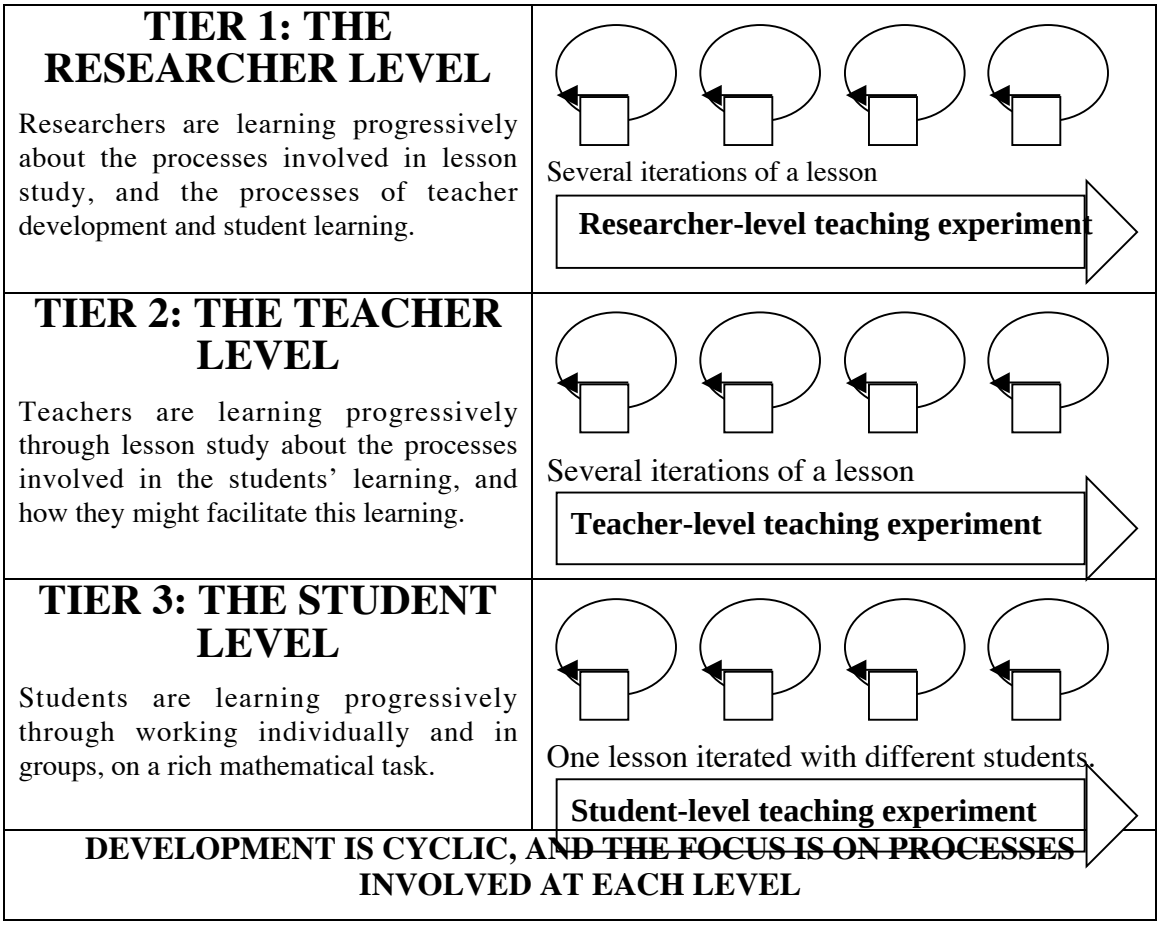

Figure 1: Lesson study as a three-tiered teaching experiment.

A three-tiered teaching experiment was a natural choice for the methodology of the research, because this form of research design involves teams of teachers and researchers working together, investigating a research question in the natural setting of the classroom, developing learning trajectories for the students with regard to the research question, meeting and reflecting on the outcomes of the experiment, and then repeating the whole process several times. The cyclic nature of the iterations of teaching a lesson on measurement, resonates also with the developmental research process described by Gravemeijer (1994), and the research is also consonant with the teacher development experiment of Simon (2000). Because space restrictions prohibit the reporting of details of learning in all three tiers, the specific research questions addressed in this paper are as follows.

1. What learning was reported by the teachers through participation in the lesson study?
2. Did the teachers judge this experience to have contributed to their professional development, and if so, in what ways?

Thus we are concentrating on the second tier in this paper. Because all three tiers are intimately connected, we shall also report on some of the learning that took place in the third tier, that of the students, and this whole paper details learning at tier 1 because it is the researchers who are reporting. But the focus is on tier 2, the learning of the teachers. These six teachers (three of grade 4 and three of grade 5) were chosen because they were known to one of the researchers, and because of their interest in participating in the lesson study.

Criteria of quality were addressed in the research by two forms of triangulation, namely that of multiple observers, and that of multiple data sources. The whole team of six teachers and two researchers reflected on the experiences of each iteration, and of participating in the lesson study. The results of the research are the negotiated interpretation by the whole team, of the data collected. There were six data sources, namely, notes taken during nine planning and debriefing meetings, audio recordings of some of these meetings, transcriptions of video recordings of lessons, lesson study grids drawn up by the grade 4 and grade 5 teachers in two teams, artifacts of students' work in lessons, and finally, field notes of presentations in which all but one of the team of six teachers and two researchers participated, at two conferences, one local and one regional.

The empirical setting (Brown & Dowling, 1998) and the choice of a lesson topic and problem, are elaborated in the next section.

Three iterations of a lesson on measurement.

Steps in the Japanese lesson study process are as follows (Stigler and Hiebert, 1999).

1. Defining the problem.
2. Planning the lesson.
3. Teaching the lesson (cycle 1).
4. Assessing the lesson and reflecting on its effect.
5. Revising the lesson.
6. Teaching the revised lesson (cycle 2).
7. Assessing and reflecting again.
8. Sharing the results (pp. 112-115).

While the team recognized that it might be necessary to adapt the process to US culture, these eight steps were all part of the study. The first seven steps were followed by a third cycle of revising, teaching and reflecting on the lesson, which was taught once by each of the six teachers (see Table 1). Presentations at a local conference on August 15, 2002, and at a regional conference on October 18, 2002, completed the eighth step.

Our program began with preparatory studies of two books (Ma, 1999; Stigler & Hiebert, 1999). After gaining familiarity with the lesson study approach, the group began, in February, meeting on a regular basis at the university for the purpose of selecting a topic and task and planning to teach a lesson by mid-April. In all, there were nine planning and debriefing meetings in addition to the three iterations of teaching the lesson.

Grade Level	First Iteration	Second Iteration	Third Iteration
Fourth Grade	April 18, 2002	May 8, 2002	June 12, 2002
Fifth Grade	April 17, 2002	May 8, 2002	June 12, 2002

Table 1: Dates of the teaching of the measurement lesson

At the meeting on March 6, all the participants had brought suggestions for possible mathematical content areas and specific topics suitable for a lesson that could be taught both in grade 4 and grade 5. Content areas that were suggested included geometry (perimeter, area, volume), fractions (equivalent fraction, multiplication of fractions), probability, and measurement of length. The researchers recognized that ownership by the teachers was important, and the group finally agreed on the following measurement task, set in the context of an imaginary radio competition, which seemed open and rich enough to facilitate students' learning of measurement in grades 4 and 5. The competitive nature of this formulation of the task may already be a departure from a Japanese cultural value of cooperation.

> "Walking in Sunshine" (Play a portion of this song, and fade out).
>
> Hey! Hey! Hey! You can be walking in sunshine when you enter out contest, "Steppin' to Cash Contest." 4th and 5th grade students, how would you like to walk into 500 dollars? You heard me right! 500 dollars! Well, you can if you enter the "Steppin' to Cash Contest." Here's all you have to do! Figure out how many footsteps it will take to walk from Normal to Peoria. If your estimate matches ours or is the closest, you could win 500 dollars! So come on, step up to win!
>
> "Walking in Sunshine" (and fade out).

The task lent itself to exploring issues of mathematical models for real situations, and allowed us to teach measurement within the context of problem solving.

Planning, preparing, and predicting.

By April 10, the planning had progressed to the following basic structure for the first iteration of the lesson, to be taught in grade 4 by Kelly and in grade 5 by Barry[2].

1. Announcement of "Radio Station Contest" by the teacher.
2. Whole-class discussion of ideas by students and teacher.
3. Work by individual students, each writing on a big yellow sheet of paper, deciding whether and how they wanted to take actual physical steps, to mark these out on the paper, to represent their thinking concerning the problem.
4. Work in groups of four students, again representing on a big white sheet of paper the results of the sharing of ideas and group activities.
5. Whole-class presentations and discussion of the results of small-group work.

Materials such as yardsticks and calculators would be made available. Students also had access to the information that there are 5,280 feet in a mile, and the distance from Normal to Peoria was taken to be 42 miles (or re-negotiated to be 40 miles in Barry's class).

A large part of the team preparation had involved negotiation of meanings of elements of the problem itself. What is a step? Is it different from a pace? How is it measured? It was

[2] All names of teachers are pseudonyms.

foreseen that students might ask some of the questions they in fact did ask: Does it matter who does the walking? Does it matter if the walker is happy or sad? Does one have to walk in a straight line, and does this make a difference? Because the aspect of predicting student responses was known to be important in Japanese lesson study, the team worked out two grids, one for each of grades 4 and 5, consisting of four columns with the following headings: learning activity; expected student reaction; guidance/advice (to be provided by the teacher); and finally the actual reaction of the students (to be filled in after the teaching of the lesson). As an example, a small part of a grid for grade 5 is presented in table 2. A final grid was completed by the grade 5 teachers as a group after the third iteration, that is, after all three grade 5 teachers had taught the lesson, as a summary of "what happened" in all three iterations, taken in order. Thus the final grid shows (indirectly) the changes that took place between iterations as a result of reflections and debriefing by the whole group. Because of space restrictions, only two sections – introduction and small-group work - of Barry's lesson (that is, the first iteration) are presented in table 2. (Stages omitted are the "yellow sheet" work of individual students prior to the session in small groups, and the whole-class presentations and questions that followed the "white-sheet" work in groups.)

Issues that arose in the teachers' reflections were the role of questioning, the structuring influence of the tools that are provided (including the calculator and the yardstick), students learning through their mistakes, "allowing students to struggle with a process, rather than a focus on one correct answer or desired destination" (Barry, August 15). Some of these issues are discussed in the next section.

CONCLUSIONS FOR PROFESSIONAL DEVELOPMENT

The teachers made numerous reflective comments about the value of meeting with other teachers for the purpose of promoting student's knowledge and problem solving abilities. All six agreed that they had never had another educator in their classroom to offer them constructive ideas about helping children understand and reason through mathematics (comments from a meeting on June 12, 2002). Barry elaborated on this (August 15), "You had other colleagues there in the room with you. Usually that means they are there to watch me, and critique. But now, these others were watching what I was watching." All six teachers were encouraged that they could study the ways their students were learning within the immediate situations of their classrooms. This point illustrates Stigler and Hiebert's (1999) fourth principle for lesson study, "Make improvements in context."

In a related observation, the teachers shifted the way they participated in classroom observation. Beginning with the first round of the lesson in mid-April, the teachers who

Learning Activities	Expected Student R	**Guidance/Advice**	Actual Reaction
Introduction Pose question to entire class: "How many steps is it from Normal to Peoria?" Have class clarify things they need to know in order to solve problem What do you know? What do you need to know in order to solve this problem?	Wonder if it's a real contest How many steps are in a mile? How many miles is it to Peoria? How big is a step?	Write question on the board. Write "40 miles" on the board We're going to assume that's it	*Barry's Class:* How many steps are in a mile? What is the exact number of miles to Peoria?
Group work Students take yellow paper to the pre-assigned groups and are asked to develop a strategy to solve the problem Instructed to ask questions, share information… Materials: large pieces of white paper and a yardstick At some point during the process, teacher may want to reconvene the class to share questions that are being asked (not strategies)	Ask whose steps to measure What is a step? Some students will measure feet, rather than steps Expect students to watch other groups Actually take steps and begin to measure Some computation Begin talking about an "average" step	Redirect the original question Would _____ make a difference? What do you think a step is and why7? Show me how you're going to walk to Peoria We want to see a visual representation, or a drawing Is that what your picture represents? Watch for inconsistencies in what they're physically doing and how they're representing it	How many yards are in a mile? I have a math book. What do we need to look up? How many feet in a mile? We're going to estimate the steps in a mile Groups began taking steps Students performing calculations on their yellow papers Students counting steps on yardstick Resources being used or requested: (textbook, rulers, calculators, floor tiles) Began drawing on big sheets of paper Discussed measuring toe to toe, heel to heel and toe to heel Students decide to find an average step for their group Students jumped to simple calculations in an effort to solve quickly "It'd be easier to walk to Peoria than to go through this."

Table 2: Part of Barry's grade 5 lesson study grid.

were not presenting were observing students by moving rapidly from group to group, much as they might have done were they responsible for the lesson themselves. In contrast, one of the researchers focused her observations on only one of the groups of students in the classroom throughout the entire lesson. The teachers noticed this contrast in approaches, and we discussed the different purposes for each at the meeting on May 1. As a group, they decided to use this "teaching experiment" style for questioning and following one or two students closely through the duration of a lesson. After meeting on May 8 (after the second iteration), they commented on how much more they could learn about the lesson as a dynamic process by watching a specific group progress through the entire process, and chose to use the technique again on June 12 (third iteration). Barry reflected as follows,

> Instead of me figuring out all the students, we each watched a 'pocket' of that class. Here is what I saw, this is what the other teachers helped me do: I shifted from accomplishing a particular goal. I moved instead to look at what the kids are thinking and how I could help them grow. The different environment [of the lesson study approach] shifted my focus.

He attributed the growing ability to see what children need to grow in their mathematics to this particular research environment. This kind of observation can form a critical part of teachers' classroom practice, supporting and extending an "informal assessment" component of their pedagogy.

One barrier the team had to overcome was the difficulty of changing from a typical emphasis on classroom routines, and on the sequencing of student exercises into the substantive issues for lesson study. We came very slowly to this latter emphasis. It took a long time and much effort to ask new questions: how do children think about a mathematical idea, how does that idea fit in the curriculum, and what kind of strategies do children use, or need to use to investigate that mathematical idea? The six teachers in our group were initially focused on crafting a lesson together. But our group progressed quite slowly into the substantive work of anticipating students' reasoning and strategies related to the mathematical concepts. Resonating with Stigler and Hiebert's second and third principles, "Maintain a constant focus on student learning goals," and "Focus on teaching, not teachers," lesson study only succeeds where teachers genuinely shift to assessment of the students' thinking within a classroom where a lesson is being taught without so much attention to the words and actions of the teacher. In a collaborative teaching experiment such as this, the lesson comes to be seen as belonging to the entire group, not to any one individual teacher: critique is then not of an individual, but an attempt to improve the lesson that then belongs to all.

FINAL WORD: WHERE ARE WE GOING?

Barry voiced it well (notes, August 15 presentation):

> A practical area that arose was that of how this process and these changes in lesson preparation and presentation impact classroom management, especially in the areas of timing and assessment. As teachers we want to work towards a point where we are less focused on "neatly wrapping up the lesson" in the allotted time, and more focused on the process and what the students are learning through that process of mistakes, conversation, questioning, self-evaluation, etc. We also want to work towards a point where we can find ways of assessing this process and find ways of making that assessment work within the boundaries and confines of our current evaluation system.

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